MULTIMEDIA UNIVERSITY

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FINAL EXAMINATION

TRIMESTER 2, 2017/2018

EMG4076 – ELECTROMAGNETIC INTERFERENCE

(TE)

12 MARCH 2018
9.00 A.M.–11.00 A.M.
(2 Hours)

INSTRUCTION TO STUDENT

1. This question paper consists of 5 pages including cover page with 4 Questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the answer Booklet provided.

Question 1

(a) Consider a three-wire configuration as shown in **Figure Q1a**. Conductor 1 is connected to a high voltage analog signal (V_S=10V) with R_{1S}=100Ω and R_{1L}=2kΩ. Conductor 2 is carrying a low voltage analog signal with R_{2S}=R_{2L}=50Ω. G is the common ground connection. The diameter d of the conductors is 0.5mm, spacing D_{12}=10mm and D_{1G}=D_{2G}=20mm. The length of each wire, l is 100mm. The insulators around the conductors have a dielectric constant of 8 where.

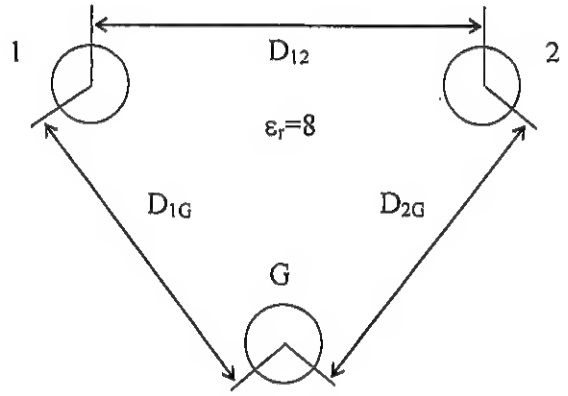

Figure Q1a

(i) Calculate approximate values for C_1, C_2 and C_G (as in **Figure Q1a**).

[5 marks]

[Hint: $S_1 + S_2 = \frac{\ln[2D_{12}/d]}{\pi\varepsilon_r\varepsilon_o l}, \varepsilon_0 = 8.854\times10^{-12} F/m$]

(ii) Determine the maximum noise voltage on conductor 2 due to capacitive coupling only.

[8 marks]

[Hint: $V_N = \frac{S_G V_S}{R_{1S}} \frac{j\omega}{(j\omega+s_a)(j\omega+s_h)}$]

(iii) Sketch the frequency response for the above condition.

[4 marks]

(iv) It is required that the noise magnitude in wire 2 must be less than 0.8 volts. Is this requirement satisfied? If no, suggest any possible remedy to reduce the noise voltage.

[3 marks]

(b) Describe shielding effectiveness and state **THREE** (3) methods to improve shielding effectiveness for magnetic coupling.

[5 marks]

Continued...

Question 2

(a) The Thevenin equivalent circuit in **Figure Q2a** shows a load connected to the end of a power distribution bus with Z_o as the characteristic impedance and a decoupling capacitor C_d connected in parallel. I_T and I_L denote the transient load current and DC load current respectively.

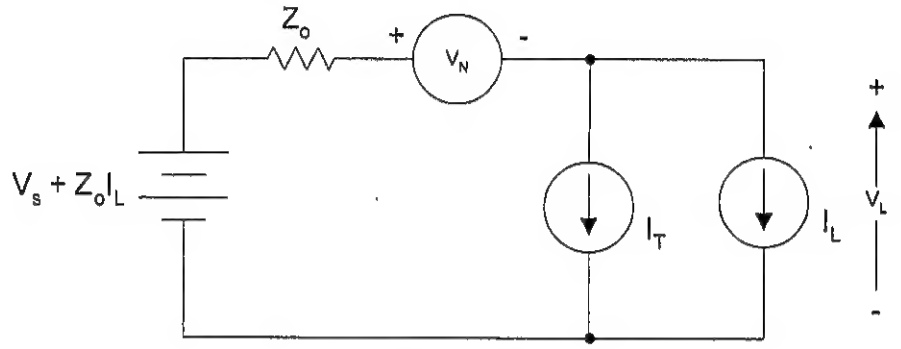

Figure Q2a

(i) By using Kirchhoff's Current Law and initial condition $V_L = V_s$ at $t = 0$, show that the load voltage V_L can be written as $V_L = V_S - Z_o I_T\left[1 - e^{-t/Z_o C_d}\right]$.

[8 marks]

(ii) Derive an expression for the transient load voltage and a formula to obtain the required C_d?

[6 marks]

(b) In what condition capacitive and inductive coupling can be treated separately?

[2 marks]

(c) With the aid of diagrams, describe the two types of single point ground system and briefly explain the differences between them.

[6 marks]

(d) Shielding theories that apply to idealized cases usually predict a much higher shielding effectiveness than any practically achievable shielding performance. State **THREE** (3) factors that cause the departures from the concept of perfectly closed screen.

[3 marks]

Continued...

Question 3

(a) A microwave transmitter operates at 1200 MHz and requires forced-air cooling. The air duct is 0.25 m wide, 0.1 m high and 0.5 m long. The duct behaves as a waveguide, but its cutoff frequency is too low to attenuate the 1200 MHz stray radiation. The cutoff frequency can be made higher by inserting baffles lengthwise in the duct, thus forming smaller rectangular tubes.

i. What is the cutoff frequency of the original air duct?

ii. How many vertical and horizontal baffles are necessary to raise the cutoff frequency to 3600 MHz?

iii. What is the attenuation to the 1200 MHz signal as a result of the baffled air duct?

[2+5+5 marks]

[Hint: $\gamma_{mn} = \sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2 - k^2}$]

(b) Describe **FIVE** (5) design rules for radiated electromagnetic compatibility (EMC).

[5 marks]

(c) What is the skin depth for annealed copper at a frequency of 10 MHz? How thick must a copper shield be to provide an absorption loss of 100 dB at this frequency?

[4 marks]

[Hint: $\delta = \sqrt{\frac{2}{\mu\omega\sigma}}$, $\mu_0 = 4\pi \times 10^{-7}\, H/mm$, $\sigma_{Cu} = 5.82 \times 10^7$ S/m and $\varepsilon_0 = 8.854 \times 10^{-12}\, F/m$]

(d) The relative conductivity of a certain grade of steel is 0.1, and the relative permeability is 500 at a frequency of 10 MHz. Compute the skin depth of this material at 10 MHz. How thick must a steel shield be to provide an absorption loss of 100 dB?

[4 marks]

Continued...

Question 4

(a) Define Electromagnetic Interference (EMI) and explain the elements that need to exist in order for EMI to occur.

[5 marks]

(b) Describe **TWO** (2) modes of EMI coupling.

[4 marks]

(c) Consider the PCB trace in **Figure Q4c** below. Trace 1 and 2 carry signal and the return is the ground plane. If Trace 1 is connected to input signal, sketch the equivalent circuit and derive the expression for the capacitively coupled noise at Trace 2. Assume the termination impedance on all traces are high.

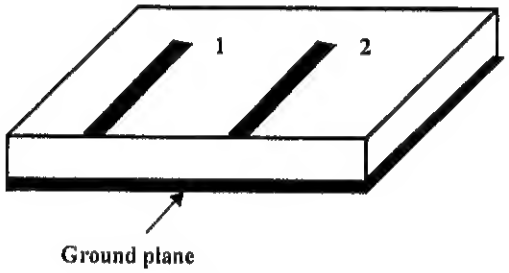

Figure Q4c

[6 marks]

(d) Sketch the setup of a typical radiated RF susceptibility test. Describe theoperation of the measurement system.

[10 marks]

End of paper.